TRANSMITTAL LETTER (General - Patent Pending)	Docket No. AGFA1-3242

In Re Application Of: Vande Velde et al.

Serial No. 10/080,143	Filing Date 02/21/2002	Examiner	Group Art Unit 2622

Title: **ADEQUATE QUANTISATION IN MULTILEVEL HALFTONING**

<u>TO THE ASSISTANT COMMISSIONER FOR PATENTS:</u>

Transmitted herewith is: **Priority Document, Patent Application No. 01000052.9**

in the above identified application.

☒   No additional fee is required.

☐   A check in the amount of   is attached.

☒   The Assistant Commissioner is hereby authorized to charge and credit Deposit Account No.   **501490 AGFA**
as described below. A duplicate copy of this sheet is enclosed.

☐   Charge the amount of

☒   Credit any overpayment.

☒   Charge any additional fee required.

_____
Signature

Dated: April 11, 2002

John A. Merecki
Reg. No. 35,812
Hoffman, Warnick & D'Alessandro
Three E-Comm Square
Albany, NY 12207
(518) 449-0044

CC:

Europäisches Patentamt	European Patent Office	Office européen des brevets

Bescheinigung   **Certificate**   **Attestation**

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.	The attached documents are exact copies of the European patent application described on the following page, as originally filed.	Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr.	Patent application No.	Demande de brevet n°
	01000052.9	

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

DEN HAAG,DEN
THE HAGUE,   12/02/02
LA HAYE,LE

EPA/EPO/OEB Form _ 1014   -02.91

Europäisches
Patentamt

European
Patent Office

Office européen
des brevets

Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

Anmeldung Nr.:
Application no.:
Demande n°: **01000052.9**

Anmeldetag:
Date of filing: **09/03/01**
Date de dépôt:

Anmelder:
Applicant(s):
Demandeur(s):
AGFA-GEVAERT

2640 Mortsel

BELGIUM

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:
Adequate quantisation in multilevel halftoning

In Anspruch genommene Prioriät(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

Staat:
State:
Pays:

Tag:
Date:
Date:

Aktenzeichen:
File no.
Numéro de dépôt:

Internationale Patentklassifikation:
International Patent classification:
Classification internationale des brevets:

H04N1/40, H04N1/52

Am Anmeldetag benannte Vertragsstaaten:
Contracting states designated at date of filing: AT/BE/CH/CY/DE/DK/ES/FI/FR/GB/GR/IE/IT/LI/LU/MC/NL/PT/SE/TR
Etats contractants désignés lors du depôt:

Bemerkungen:
Remarks:
Remarques:

THIS PAGE BLANK (World)

[DESCRIPTION]

FIELD OF THE INVENTION

5   The invention relates to a method for multilevel halftoning of grey-scale and colour images. In a specific embodiment the invention is related to an improved method for multilevel error diffusion.

10   BACKGROUND OF THE INVENTION

      Traditionally the halftoning for images for printing is done using only two levels. The continuous tone density value of a pixel to be reproduced is approximated by printing an appropriate

15   percentage of high density dots within the area representing the pixel. At a particular position either a dot or no dot can be placed.

      Today, ink-jet as well as electrophotographic printers exist that render N>2 intensity or density levels. The inkjet printers are

20   able to deliver variable droplet sizes or use multiple inks of the same hue, but different densities, both procedures resulting effectively in reproduction of multiple possible density levels for one printed dot. Halftoning algorithms, such as error diffusion may be extended to the multilevel (i.e. N>2) case. See e.g. US patent

25   4,680,645 by Dispoto et al describing a method for rendering a grey scale image with variable dot sizes. A continuous tone image is an image containing multiple grey levels with no perceptible quantization to them. In a different multilevel halftoning technique all different continuous tone pixel values within a range

30   (e.g. 0-255) are mapped onto the N allowable values within the range N < 256. These N allowable values correspond to the N density levels which can be rendered by the multilevel system.

      The basic error-diffusion algorithm is illustrated in Fig. 1 and works as follows. The first pixel value 21 of the original

35   image 22 is quantized by a quantizer 23 to the nearest allowed value to obtain the output pixel value 24. The quantization error 25, i.e. the difference between the continuous tone input value 21 and the

output pixel value 24, is diffused to future pixels. This may be done by storing the error 25 into a special buffer 26. For the next pixels the method quantizes, the modified pixel value 27 = (original pixel value 21 + error 25 received from past pixels which is read

5 from the buffer 26) to an allowed quantization level to obtain an output pixel value 24 and again diffuses the newly obtained error 25 to future pixels via the error buffer 26. A more elaborate description can be found hereinafter. Several refinements can be built into the algorithm to avoid the creation of artefacts, such as

10 worms. Examples of such refinements can be found in "Digital Halftoning", R. Ulichney, Cambridge MA, MIT Press, 1987.

Using more than two allowed values (density levels) i.e. "on" and "off" or high and low density enhances the image quality of the halftone image 28 a great deal compared to only using minimum and

15 maximum values (density levels).

Due to the diffusion of the error 25 however, the output pixel value 24 (density level) wanders around over several allowed output levels of the whole range in a multilevel system. This wandering is fortified when additional features are built into the algorithm,

20 such as putting noise on the diffusion weights (Ulichney) or on the quantizer 23, or using an imprint to get a more homogeneous point distribution, e.g. US-A- 5 535 019 Eschbach. The imprint provides a homogenous printed spot distribution in highlighted and dark areas by an increase or decrease of the threshold level based upon a

25 regional input level. When a white pixel is set the threshold is raised while the threshold is lowered when a black pixel is set providing less chance obtaining that another white or black pixel respectively is printed.

This causes that sometimes output pixel values 24 are further

30 away from the original input pixel values 21 than is strictly necessary or desirable. This results in the production of intensity levels giving unwanted, noticeably contrast between halftone dots giving rise to a noticeably more grainy image. The described phenomenon happens mostly at tone levels close to a quantization

35 level. A solution to this problem has not yet been provided in the prior art methods.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide an improved method for a multilevel halftone reproduction system avoiding unwanted density transitions between neighbouring pixels.

5   It is a further object of the invention to minimize dot noticeability in multilevel halftoning.

In US-A-5 991 438 (Shaked et al.), the set of halftone colours is limited to tetrahedra in colour space to minimise dot-noticeability metrics. The method explained there has however the

10   drawback that it is restricted to bi-level colour halftoning.

SUMMARY OF THE INVENTION

15

The above mentioned objects are realised by a method and apparatus having the specific features set out in claims 1,8 and 9. Specific features for preferred embodiments of the invention are set out in the dependent claims.

20   Further advantages and embodiments of the present invention will become apparent from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

25

Fig. 1   illustrates a basic multilevel error-diffusion scheme.

Fig. 2   shows a scheme according to the current invention.

Fig. 3A and 3B show a comparison of the output result between an error-diffusion method not using the invention and a similar

30   error-diffusion method using the invention.

Fig. 3A shows the output result by using a state of the art multilevel error-diffusion method of an image having a gradually changing density.

Fig. 3B shows the output of the image used for Fig 3A, as obtained by

35   using the error-diffusion method according to the invention.

Fig. 4   shows restriction of the quantization colours to the corners of sub-cubes.

DETAILED DESCRIPTION OF THE INVENTION

A prior art and a preferred method according to the invention are
5　described and compared hereinafter in relation to the drawings.
　　　Fig. 1 shows a scheme of a state of the art multilevel error-
diffusion system.　An original image 22 has pixels having an input
pixel value 21 in the range of 0-255.　The input pixel value 21 is
read-out, possible error values 25(quantization errors) obtained
10　from previous quantized pixels are added to the input pixel value 21
in adder 28 and the modified pixel value 27 is mapped to an allowed
level e.g. the set formed by values 0, 15, 31, 47,...255 within the
range by comparing the cumulative value 27 to the different
threshold values by the quantizer 12 thus determining the different
15　allowed quantized values 24 of the output pixels to be reproduced by
the output system.　Normally a cumulative value 27 is mapped to the
closest allowed value. This can be done by having the threshold
values in the quantizer exactly in between the allowed quantized
levels. The difference between the cumulative value 27 and the
20　output value 24 is stored as a quantization error 25 which is
distributed over subsequent neighbouring pixels.　These error values
are stored into the error buffer 13 for use when processing later
neighbouring pixels.　Due to the addition of errors 25 of previously
processed pixels, it is possible that the output pixels obtain an
25　allowed value as output pixel value 24 having a large deviation
compared to the original value 21 of the input pixel.　This can give
rise to unwanted, noticeable graininess in the rendered output image
as described above.　A result having such defective pixels is given
in Fig. 3A.　The reproduction of an electronic image 22 having a
30　gradually changing density is shown.　As can be seen, in the lighter
part of the image, some pixels having an abnormal high density occur
giving rise to an unwanted distortion of the image.　On the upper
side of the image, some pixels showing an abnormal brightness are
present, also giving rise to a distorted image. Without using the
35　current invention, white pixels invade areas occupied by black and
grey pixels, while black pixels invade areas occupied by white and
grey pixels.

This problem can be solved by using a scheme according the invention as described hereinafter. As shown in Fig. 2 the input pixel value 21 is read out and, if needed, quantization error values 25 obtained from previous pixels are added in adder 28. An additional control 29 to the error diffusion scheme is added in this scheme.

In a preferred embodiment the input pixel value 21 is read out by the control circuit and out of all possible reproducible output values, i.e. allowable values or density levels reproducible by the output system, only the quantizer values just below and above or equal to the original input pixel value 21 are used for quantizing the modified input pixel value 27 and are thus allowed as output pixel value 24. Out of all reproducible and thus allowable output pixel values only the values just below and below or equal to the input pixel value 21 are allowed as output pixel value 24.

The aim is to guarantee that the output pixel value 24 obtained by quantizing the modified pixel value 27, and thus the resulting output density, is close to the original input pixel value 21. By restricting the allowed levels of the output pixel value 24 for each specific pixel to the allowable levels just above or below or equal to the original input pixel value 21 of the pixel, the occurrence of conspicuous density deviations of certain pixels resulting in a distorted image is avoided. In this way there is for the N-level error diffusion at each pixel a choice between maximum two allowed levels only and not all N allowable levels as in the algorithm according to the prior art.

More generally, in determining the output pixel value 24 based upon the modified pixel value 27 of a specific input pixel value, only a real subset of allowed quantizing values or threshold levels is used by the quantizer. A real subset is a subset having at least one element and which has less elements than the original set. In this case when using a N-level multilevel system there are N different allowable values for quantizing the input values. For this case it is desired that a real subset of allowed levels has N_p elements where

N_p is an integer and

$0 < N_p < N$

The choice of the allowed quantizing values forming the subset can be done using several criteria.

5 Preferable the N_p allowed values forming the real subset are selected according the original input pixel value 21 readout by the control circuit 29.

In another embodiment the subset of allowed values can be defined by the input pixel values 21 of the neighbourhood around the specific

10 input pixel.

Preferably the allowed values forming the subset can be restricted to the allowable values just above or below or equal to the original input value 21 of the pixel, as mentioned above.

When using a multilevel system having a high number of closely

15 spaced density allowable levels which can be rendered, it is possible to include also other allowable values lying further away from the original input pixel value 21 resulting in a larger set of allowed values.

20 Intuitively there is no need to use more than two allowable levels to render a particular value. The levels just below and just above the actual input pixel value 21 should suffice. An output image using the method according to the invention can be seen in Fig. 3B. No pixels having a conspicuous deviating density value can be seen,

25 resulting in a smooth density gradation from the upper dark area to the lower brighter band.

In a more specific example, let all allowable output pixel values, corresponding to density levels, in a multilevel output

30 system be Q0<Q1<Q2<Q3. Suppose the original input pixel value p is such that Q1≤p<Q2. Let m denote the modified pixel value 27, i.e. the original pixel value 21 p with added quantization error values 25 from previous processed pixels. The chosen quantization value Q is

35     $Q = Q1$ if $|m-Q1| \leq |m-Q2|$

    $Q = Q2$ if $|m-Q1| > |m-Q2|$

The subset containing the allowed values is restricted to Q1 and Q2
by the control circuit 29.
The Q0 and Q3 levels are excluded as quantizing value for the pixel
value p.

5   The proposed method can be extended to all multilevel systems
having the capability of reproducing more than two density values
for one pixel.

The control circuit can also work in an alternative ways
10   - A possible embodiment can be created by controlling the error
values of previous pixels which are added in adder 11 before the
cumulated value is send to the quantizer 12. When e.g. the input
pixel value 21 has a value of 35, the error 25 to be added = -7 and
the output pixel values are 0, 16, 32, 48, 64... 255, then the error
15   25 which can be added limited so that it is restricted to the
interval [-3:13], in this case the limited error will be limited to
-3 so the modified pixel value 27 will remain within the interval
[32:48], in this case 32. In this way the only possible results for
the output pixel value = 35 will be 32. The value of the limitation
20   of the correction value becomes the new error 25 which is to be
transferred via the error buffer to the subsequent processed pixels.
Thus it can be checked if the error values to be added to the input
pixel value are likely to produce an increase or decrease of the
cumulated value supplied to the quantizer which would yield a
25   notable deviating output value.
In this case the error data added in the adder are limited so as to
ensure only output values near the value of the input pixel, thus
leading to an output picture without notable deviating output
pixels. Corrections of error values due to limiting are further
30   distributed to subsequent processed pixels.
In another embodiment the cumulated pixel value 27 can be corrected
by a control circuit to obtain a corrected cumulative input value
closer to the pixel input value 21 so that the result of the
quantizer is close to the original input pixel value avoiding
35   deviating density values in the output image.

The proposed method can also be directly extended to the rendering of colour images in a multilevel colour imaging system. Each separation image or colour component, i.e. the sub-image or image component to be printed with a single ink, may be treated as a separate grey-scale image and processed as such by the method according to the current invention.

One such known multilevel colour image reproducing apparatus is the digital press ChromaPress (Trademark owned by Xeikon N.V.) which uses up to 16 density levels for each colour to render continuous tone images using multilevel halftoning. Reproduction of colour component images can be done in a CMY system where only 3 inks are used for reproduction. Other system can use the CMYK system where also black is used for rendering the colour images. Some sytems are even using more different inks to reproduce a colour image.

For each colour component, input pixel values 21 are supplied to the quantizing process. After quantization of the input pixel value 21 of a colour component for a pixel the output pixel value 24 corresponds to an amount of ink of this colour used to render the image pixel.

Without the control circuit 29, deviating amounts of ink can be used for rendering the colour component, due to quantization errors, resulting in conspicuous colour deviations in the output image. When using the extra control circuit 29 only colours will be rendered which are close to the original input colour.

Generally the input pixel colour values 21 are quantized to obtain corresponding output pixel colour values 24 to provide rendering of the colour pixels on the multilevel colour output device. Instead of allowing all allowable colour values, corresponding to every reproducible colour, as a possible result of the quantization, for pixel p the allowed results which can be obtained are preferably restricted to a subset S_p of all allowable colours.

Having N_1 levels for ink 1, N_2 levels for ink 2,…, N_k levels for ink k, S_p is obtained as the Cartesian product of subsets S_{1p}, $S_{2p},…,S_{kp}$, where S_{ip} is the subset of allowed values defined for the i-th ink at pixel p: $S_p=S_{1p}x…x\ S_{kp}$.

A Cartesian product of sets (tables) is formed by all possible combinations of elements(rows) from the sets(tables). If one set has p elements and the second has q elements, the resultant set will have p x q elements.

5

Preferably this results to the following restriction. Having N_1 levels for ink 1, N_2 levels for ink 2,…, N_k levels for ink k, the k-dimensional hypercube of ink values is divided into $(N_1-1) \times (N_2-1) \times ... \times (N_k-1)$ sub-hypercubes. Constraining each of the ink

10   values in the way explained above may be achieved by restricting the quantization colour for a pixel to one of the corners of the sub-hypercube in which the pixel's original colour is situated.

An example for a colour system using CMY colorants is

15   illustrated in Fig 4. For each colorant 4 different "density" levels (N = 4) in the range 0 - 255 are allowed, resulting in a total of $4^3 = 64$ reproducible colours ($N_c \times N_m \times N_y = 64$) and 27 sub-cubes. Let a pixel having the colorant co-ordinates (240,120,230). By using the control circuit allowing for each

20   colorant only values above or below the input pixel colorant values 21 the set of allowed colorant values is restricted to the possible combinations of the two values for each colour component. This gives rise to 2 x 2 x 2 = 8 possible combinations. These 8 combinations (Np = 8) form the corners of the sub-cube in the

25   colorant space (represented by the dots). Other reproducible colour values are prohibited thus avoiding the occurrence of deviating coloured pixels. Excessive deviations of the modified input pixel value 27 due to the error diffusion algorithm are thus avoided and corrected.

30

In another embodiment, it is possible that not all colorants are quantized using the correction method. The method can be restricted to one or more colorants where a prior art halftoning algorithm would cause excessive deviations.

35

The quantization constraint discussed here is not restricted to error diffusion, but can be incorporated into other multilevel halftoning algorithms as well.

In one such method, instead of considering only the original input pixel value 21 of the pixel being processed, to decide about the allowed levels, the control mechanism 29 may use all original input pixel values 24 of pixels in a certain neighbourhood of the pixel being processed. This may eliminate unnecessary variations due to noise in the image.

The problem inherent to the prior art is therefore resolved by a local limitation of the halftone levels to a subset of all allowed levels. It will be appreciated that 'limiting' is to be understood both in the sense of actually restricting the number of levels as well as making certain levels far less attractive than other levels by including an additional penalty for them.

A possible penalty system which can be applied uses the adjustment of the threshold values determining which quantization level is chosen.

In a system without penalty, threshold value are situated exactly in between the allowable output pixel values. E.g. when allowable pixel values are : 0, 16, 32, 48, ..., the threshold values would be 8, 24, 40, ... This means e.g. that for the (modified) input pixel values 27 between 16 and 32 half of the values, i.e. the values 16, 17, 18, 19, 20, 21, 22, 23, will result in the output value 16 and the other half of the values, i.e. 24, 25, 26, 27, 28, 29, 30, 31, will result in the output value 32.

In the system having a penalty, threshold values would not be located in the centre of the quantization values. Between 16 and 32 the threshold value could be 28 so that pixel input values 16 to 27 give an output value of 16 and only 28, 29, 30, 31 will result in the output value 32.

In general the threshold value determining the quantization level is situated right in between the quantization levels as described above using Q0, Q1, Q2 and Q3. By placing the threshold level close to the value having a large deviation compared to the

original input value will give less chance that this large deviating value will be obtained as output pixel value.

For the above mentioned example the criteria for choosing the quantization value can be changed to :

$Q = Q0$ if $|m-Q1| > 2x|m-Q0|$

$Q = Q1$ if $|m-Q1| \leq |m-Q2|$ and $|m-Q1| \leq 2x|m-Q0|$

$Q = Q2$ if $|m-Q1| > |m-Q2|$ and $|m-Q1| \leq 2x|m-Q2|$

$Q = Q3$ if $|m-Q2| > 2x|m-Q3|$

This effectively changes the "threshold value" so that Q2 is less likely to be obtained than Q1.

As already noted in the background section, the proposed method is of particular advantage in combination with methods that are devised to yield more homogeneous dot distributions. One example is the use of an imprint function (US-A- 5 535 019 Eschbach). This technique is based on threshold modulation with a function, called the imprint function, which depends on the placements of the previous dots. Whenever a dot is placed in the highlight or shadow region, the threshold used for future pixels is modified such that it inhibits the alignment of dots in worm artefacts. Modulating the threshold is equivalent to modulating the modified pixel value 27 and therefore this method is extended to the multilevel case, where thresholding is replaced by quantization. Other methods that yield more homogeneous dot distributions are those of Levien (US patent 5,917,614) and Marcu (Journal of Electronic Imaging 9(1), 46-51 (2000)). These two methods eliminate worm artefacts by using distance constraints for dot placement. A minimum distance between dots is forced by the algorithm, depending on the grey level. As explained, the method of the current invention eliminates unnecessary density variations created by accumulation of errors in the multilevel versions of such algorithms. In the Levien method the error diffusion threshold is modulated using a bias value based on e.g. in function of the square of the distance to the nearest previously generated dot. This can be combined with the extra restriction of output pixel values 24 by the control circuit 29.

In the above description the input pixel values 21 of the continuous tone pixels having a value in a certain input range are

mapped to N allowed levels within the same range. It is however possible to map these input pixel values 21 to an other range, e.g. Instead of mapping the input pixel values 21 of the range 0-255 to 16 allowed levels within the range 0-255, we can map them to 16 levels in the range 0-15. The handling of errors for the error diffusion algorithm would in this case be conducted in another way but would deliver the same technical result as the above described embodiments. This can be done by multiplying the error obtained in the 0-15 range with 17 prior to addition in the adder 28.

After obtaining an output pixel value 24 for each pixel the image can be rendered by the multilevel output device. Each pixel is rendered with a density level corresponding to the output pixel value 24.

Having described in detail preferred embodiments of the current invention, it will now be apparent to those skilled in the art that numerous modifications can be made therein without departing from the invention as defined in the appending claims.

Parts list.

21.   input pixel value (signal)

22.   original image

5   23.   quantizer

24.   output pixel value (signal)

25.   quantization error

26.   error buffer

27.   modified pixel value or cumulative pixel value

10   28.   adder

29.   control circuit

- 15 -

[CLAIMS]

1. A method for reproducing an electronic image (22), comprising pixels having an input pixel value I_p (21), on a multilevel output device having N allowable output pixel values (24),
5   comprising the steps of :
   - for each pixel p choosing a real subset S_p from said N allowable output pixel values (24), said subset S_p containing N_p allowed output pixel values (24) where $0 < N_p < N$,
   - halftoning said electronic image by a multilevel halftoning
10   algorithm by quantizing, for each of said pixels, said input pixel value (21) to obtain a corresponding output pixel value (24) out of the N_p allowed values in S_p,
   - rendering said image on said multilevel output device by rendering said pixels using said obtained output pixel
15   values (24).

2. The method according to claim 1 wherein said real subset S_p is chosen as a function of said input pixel value I_p (21) in said electronic image (22).

3. The method according to any one of the preceding claims wherein
20   said real subset S_p contains two of said allowable output pixel values (24).

4. The method according to any one of the preceding claims wherein said input pixel value (21) and said allowable output pixel values (24) correspond to density levels and wherein said allowed
25   output pixel values (24) correspond to the two density levels closest to the density level corresponding to said input pixel value (21).

5. The method according to any one of the preceding claims wherein said multilevel halftoning algorithm is an error diffusion
30   algorithm.

- 16 -

6. The method according to claim 5 wherein said multilevel
   halftoning algorithm is an error diffusion algorithm with a dot
   distribution correction in low and high intensity image regions.

7. A method for reproducing an electronic colour image (22), said
   electronic colour image comprising electronic colour component
   images, by reproducing said electronic colour component images,
   comprising the step of reproducing at least one of said
   electronic colour component images according to a method
   according to any one of the proceeding claims.

8. A method for reproducing a colour image, having k colour
   components, k > 1, each colour component comprising pixels having
   an input colorant value (21), by reproducing colour component
   images, on a multilevel output device having N_i allowable output
   colorant values (24) for the i-th colour component i=1,…,k,
   comprising the steps of :
   - for any colour component i of any pixel p, choosing from said
     N_i allowable output colorant values (24) a real subset S_{ip}
     containing N_{ip} allowed output colorant values (24) where
     $0 < N_{ip} < N_i$, and
   - generating a set S_p, containing all allowed colorant
     combinations (24) for pixel p, by making the Cartesian product
     of the subsets S_{ip} for the individual colour components;
   - halftoning said electronic image by a multilevel halftoning
     algorithm quantizing for each of said pixels said input
     colorant value (21) to obtain a corresponding output colorant
     value (24) in S_p ,
   - rendering said image on said multilevel output device by
     rendering said pixels using said obtained output colorant
     values (24).

9. Multilevel output device, having N possible output pixel
   values (24) corresponding to N possible output density levels,
   for reproducing a continuous tone image having pixels with an

input pixel value (21) as a multilevel halftone image,
comprising :

- means for processing the input pixel value (21) of pixels to
  obtain a corresponding output pixel value (24),
- a control circuit (29) for restricting the allowed output
  pixel values (24) to a subset of all allowable output pixel
  values (24) according to the input pixel value (21),
- means for rendering the pixels according to the obtained output
  pixel values (24) as halftone dots having the corresponding
  density, thereby rendering the halftone image.

[ABSTRACT]

ADEQUATE QUANTISATION IN MULTILEVEL HALFTONING

5   The method reproduces an electronic image, having pixels, as a
multilevel halftone image on a multilevel output device having N
different allowed output values (possible density levels) by
- choosing for any pixel p a real subset S_p containing N_p allowed
values out of the set S of N allowed levels
10 - quantizing the input pixel value of the pixel p to obtain an
output pixel value out of the N_p values in S_p by means of a
halftoning algorithm,
- rendering the image by rendering the pixels with the output device
using the obtained output pixel values.
15
The real subset may be formed by the allowed output values closest
to the input pixel value.
The quantization may be done by an error diffusion algorithm
The used method prevents occurrence of pixels having deviating
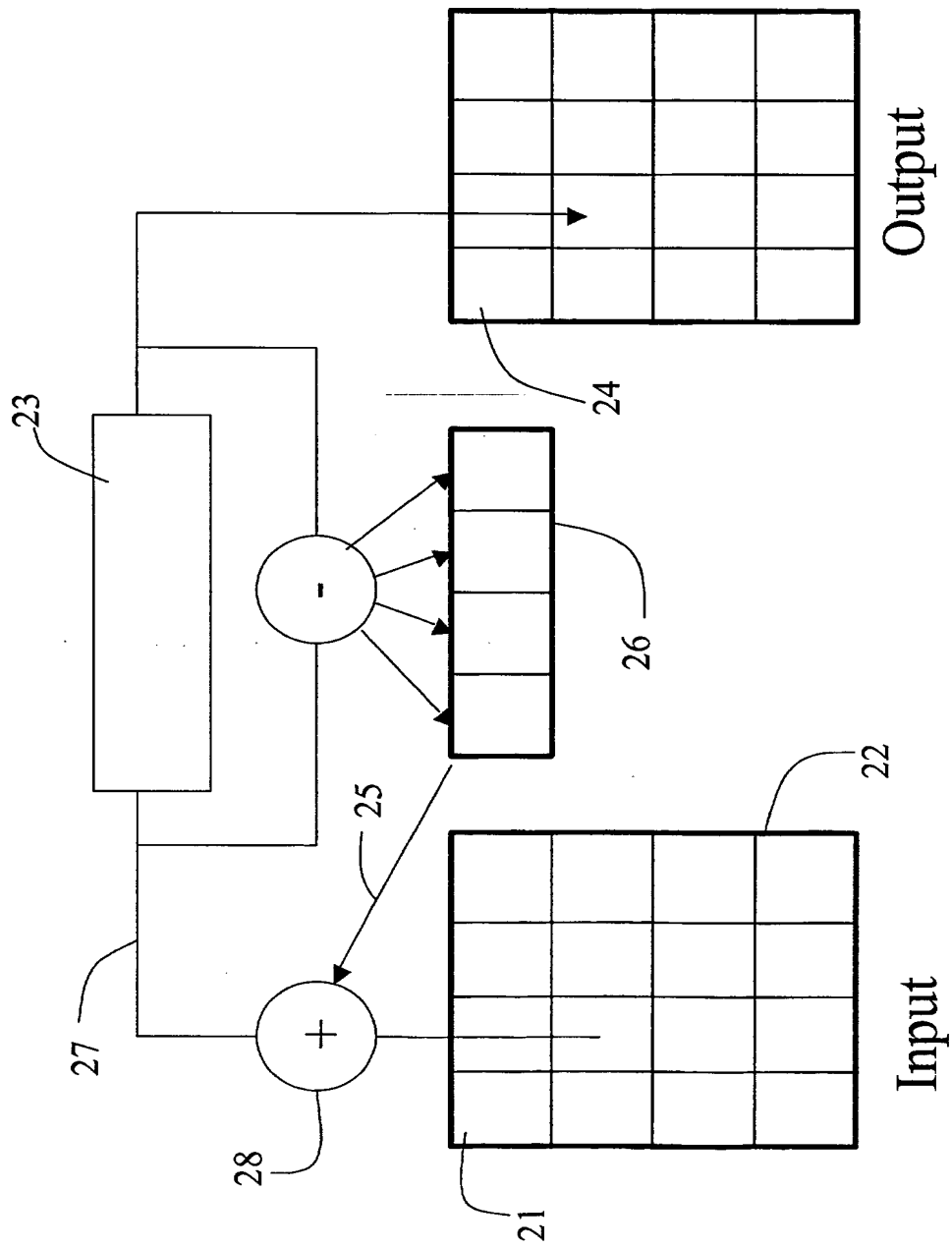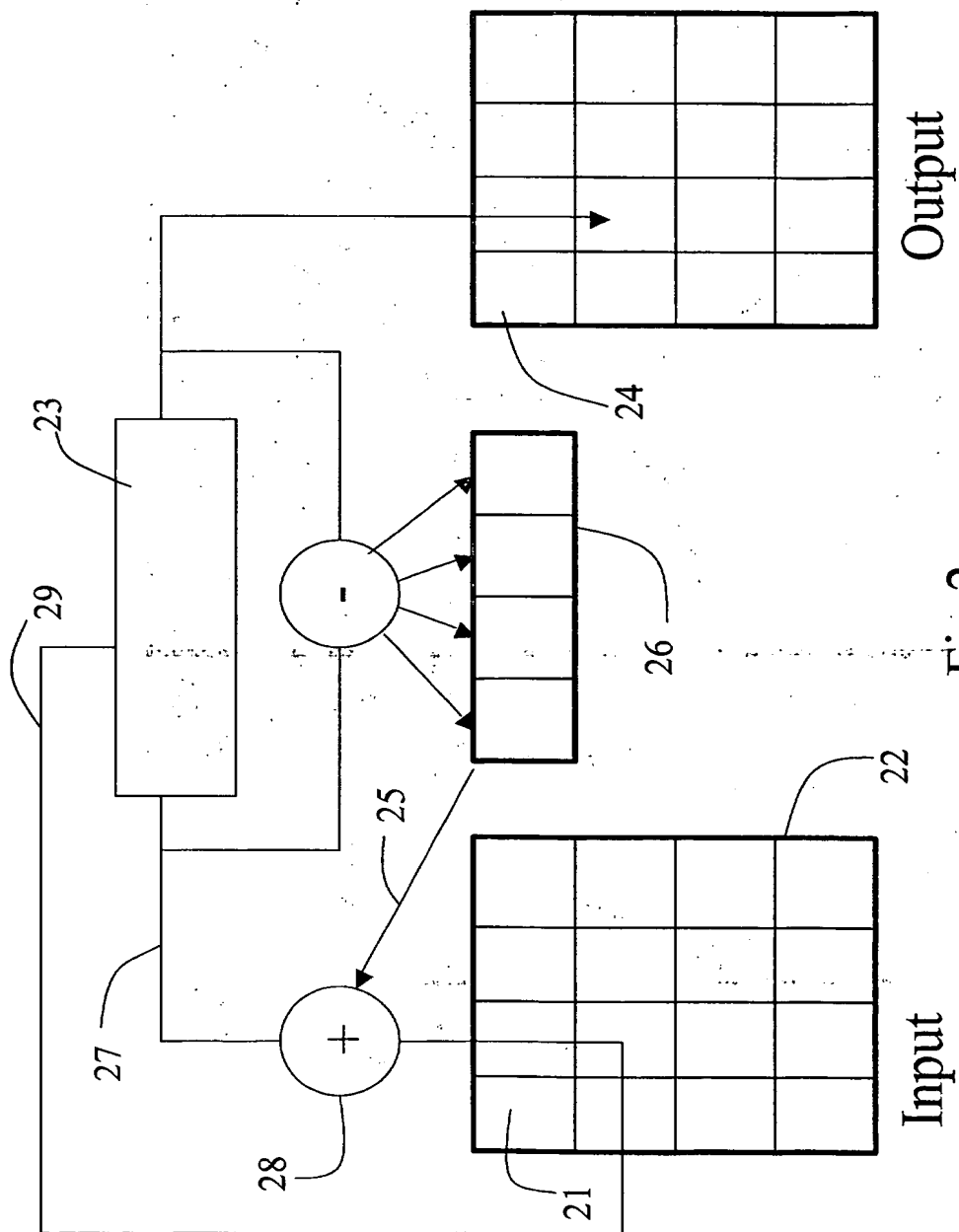20 densities distorting the output image.
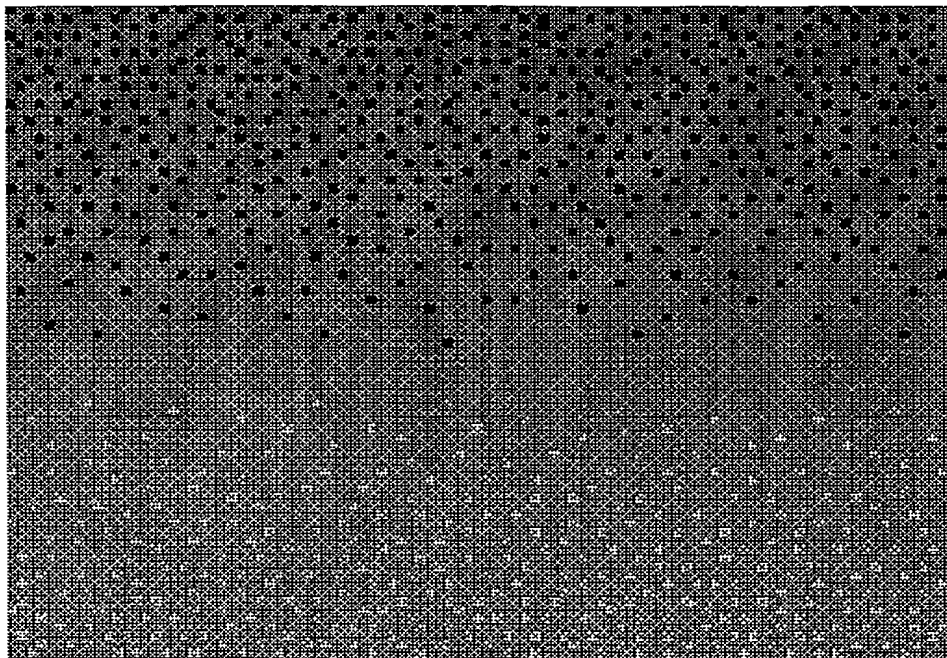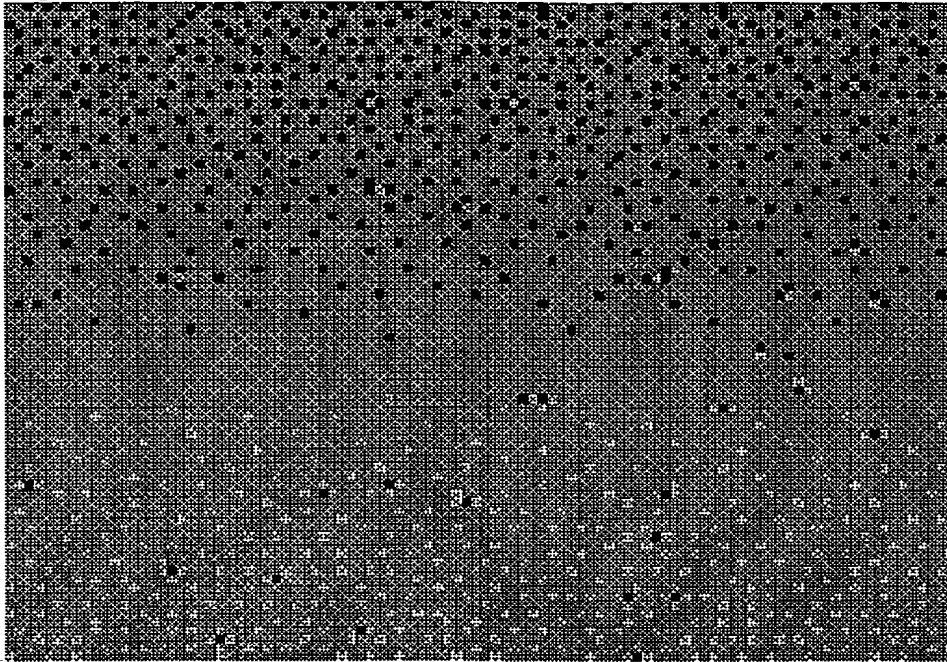
Fig. 2

THIS PAGE BLANK (USPTO)

Fig. 1

Fig.2

Fig 3A

Fig 3B

FIG. 4